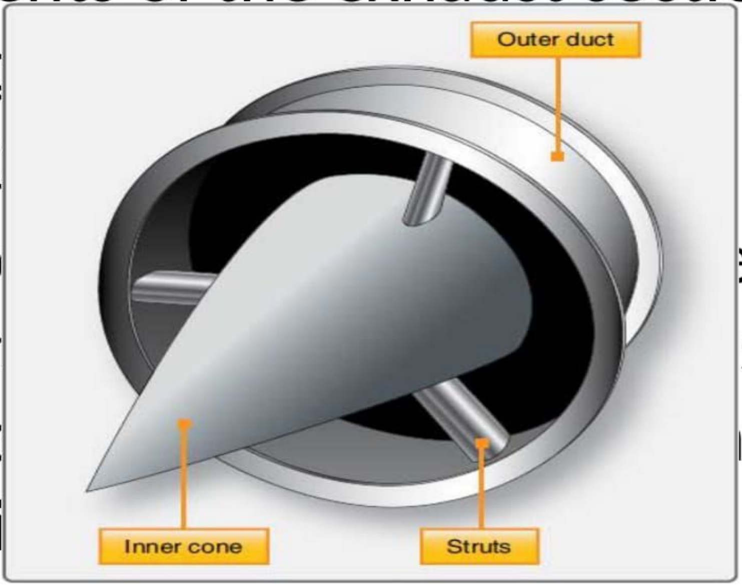
Exhaust

Introduction

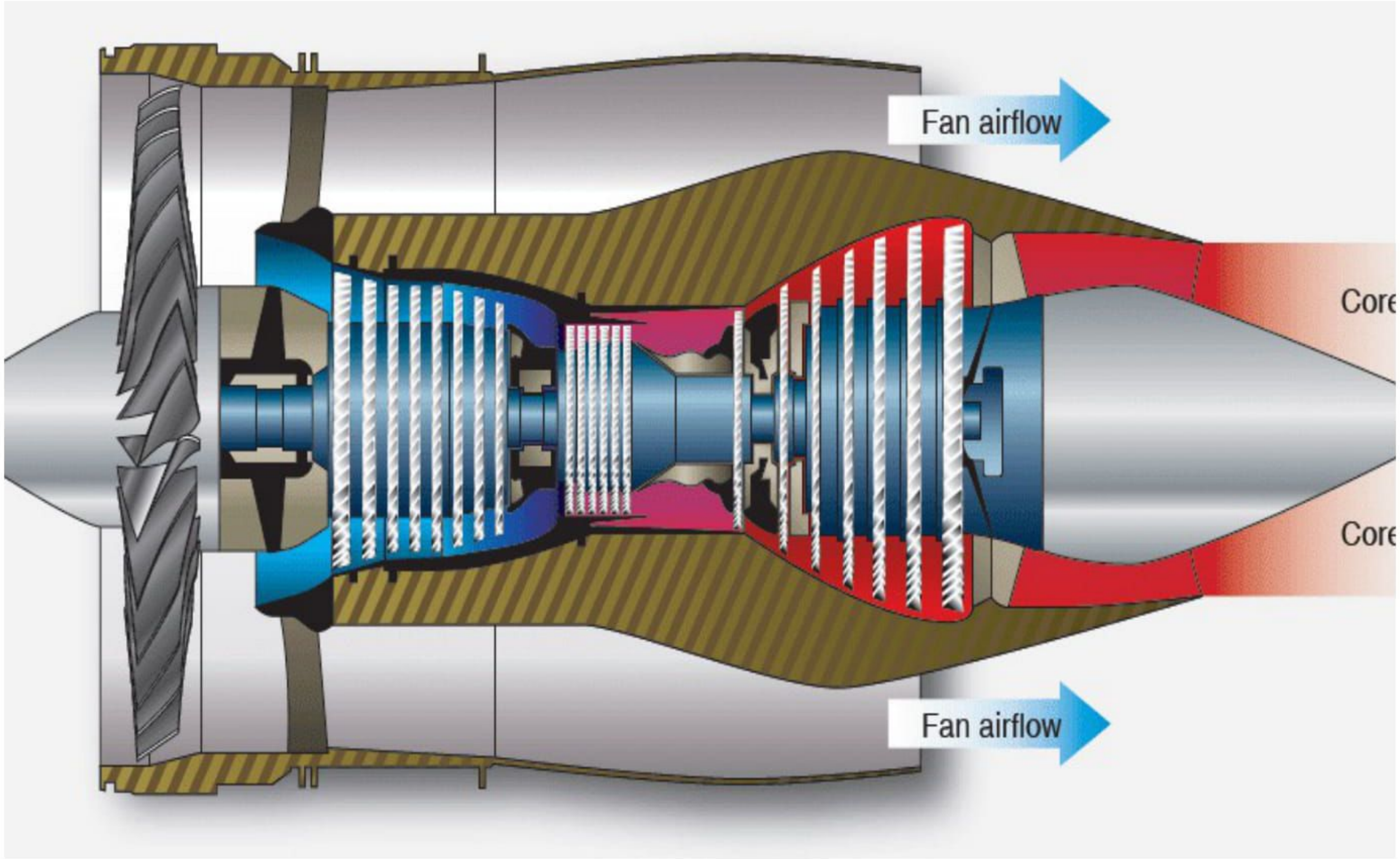
- The exhaust section is located directly behind the turbine section and ends when the gases are ejected at the rear in the form of a high-velocity exhaust gases.
- The components of the exhaust section include the exhaust c), and the exhaust nozz
- There are tw designs: the convergi s velocities an g design for supersoni



Operation

- The exhaust cone collects the exhaust gases discharged from the turbine section and gradually converts them into a solid flow of gases.
- The velocity of the gases is decreased slightly and the pressure increased.
- This is due to the diverging passage between the outer duct and the inner cone

Image



Constructional features

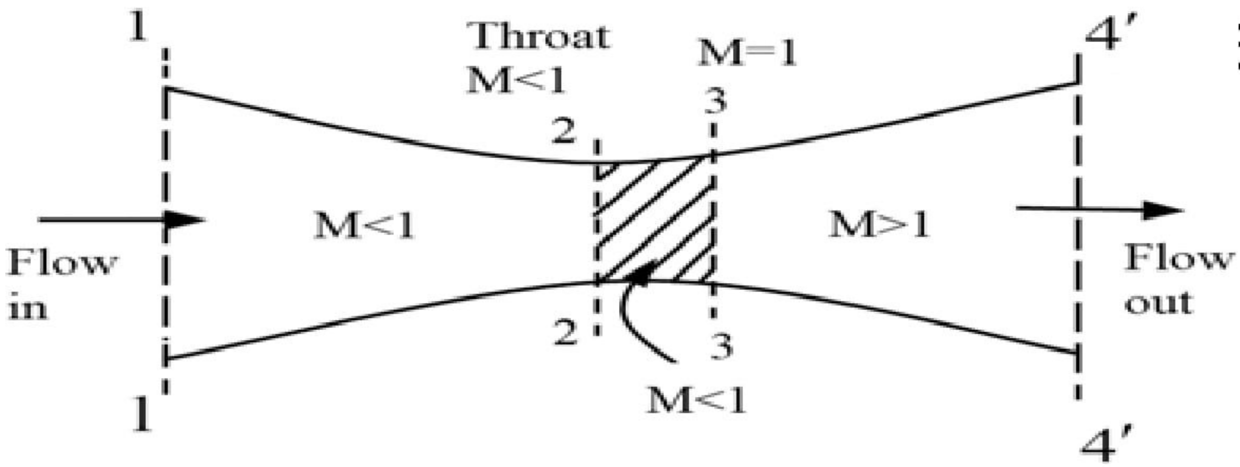
- The outer shell or duct is usually made of stainless steel and is attached to the rear flange of the turbine case. The duct must be constructed to include such features as a predetermined number of thermocouple bosses for installing exhaust temperature thermocouples, and there must also be insertion holes for the supporting tie rods.
- The struts not only support the inner cone in the exhaust duct, but they also perform the important function of straightening the swirling exhaust gases that would otherwise leave the turbine at an angle of approximately 45°.
- The tailpipe is usually constructed so that it is semi-flexible.
- The heat radiation from the exhaust cone and tailpipe could damage the airframe components surrounding these units.

CONVERGENT EXHAUST NOZZLE

- The very first part of the exhaust nozzle and the exhaust plug form a divergent duct to reduce turbulence in the airf low, then the exhaust gases f low into the convergent component of the exhaust nozzle where the flow is restricted by a smaller outlet opening.
- If the nozzle opening is too big, thrust is being wasted.
- If it is too little, the flow is choked in the other components of the engine.
- Adjusting the area of the exhaust nozzle changes both the engine performance and the exhaust gas temperature.
- A differential in pressure exists between the inside of the nozzle and the ambient air.

CONVERGENT-DIVERGENT EXHAUST NOZZLE

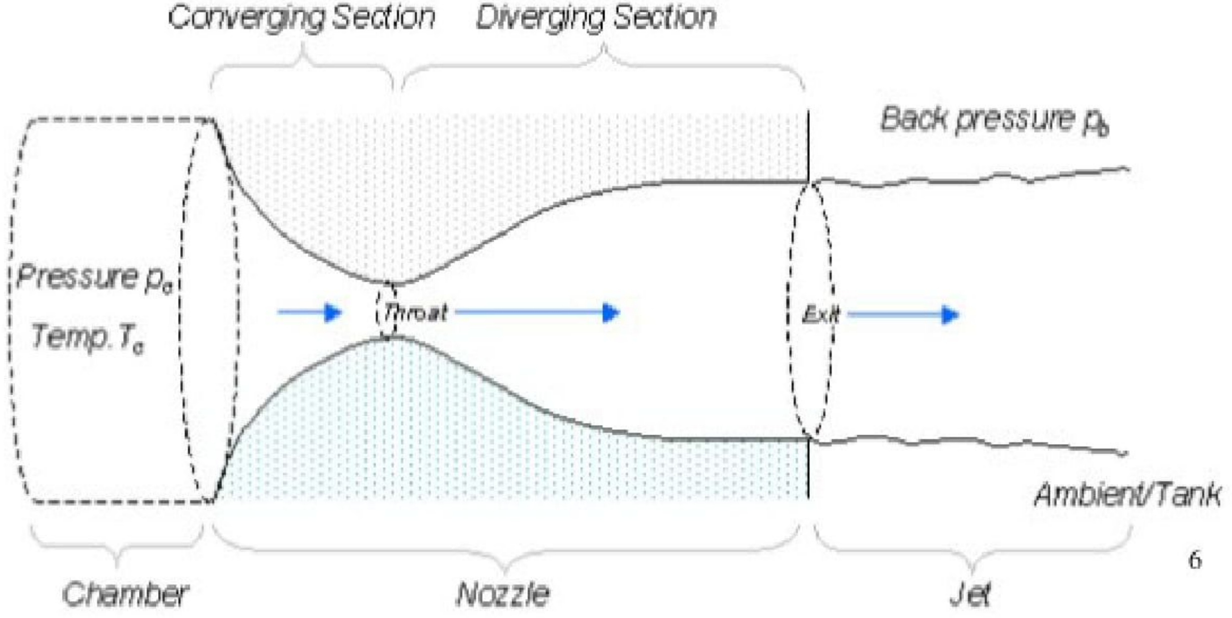
- Whenever the engine pressure ratio is high enough to produce exhaust gas velocities which might exceed Mach 1 at the engine exhaust nozzle, more thrust can be gained by u e of nozzle.



Operation

OPERATION OF CD NOZZLES

- Configuration for converging-diverging (CD) nozzle is shown below
- Gas flows through nozzle from region of high pressure (chamber) to low pressure (ambient)
- The chamber is taken as big enough so that any flow velocities are negligible
- Gas flows from chamber into converging portion of nozzle, past the throat, through the diverging portion and then exhausts into the ambient as a jet
- Pressure of ambient is referred to as back pressure



CONVERGENT-DIVERGENT EXHAUST NOZZLE

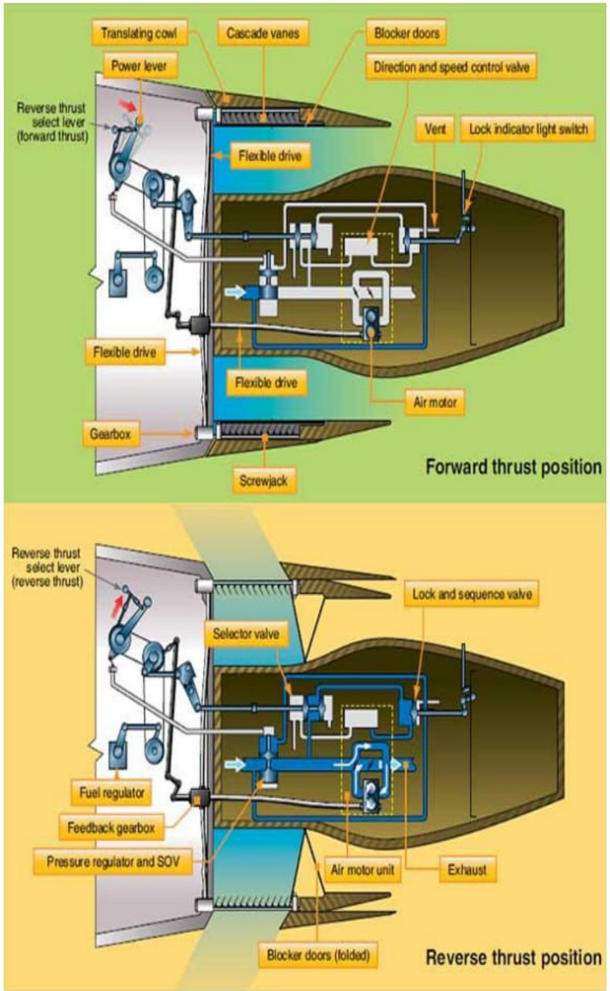
- In the convergent-divergent, or C-D nozzle, the convergent section is designed to handle the gases while they remain subsonic, and to deliver the gases to the throat of the nozzle just as they attain sonic velocity.
- The divergent section handles the gases, further increasing their velocity, after they emerge from the throat and become supersonic.
- As the gas flows from the throat of the nozzle, it becomes supersonic (Mach 1 and above) and then passes into the divergent section of the nozzle.

THRUST REVERSER'S

- Most thrust reverser systems can be divided into two categories: mechanical-blockage and aerodynamic-blockage.
- Mechanical blockage is accomplished by placing a removable obstruction in the exhaust gas stream, usually somewhat to the rear of the nozzle.
- The engine exhaust gases are mechanically blocked and diverted at a suitable angle in the reverse direction by an inverted cone, half-sphere, or clam shell.
- The clamshell-type or mechanical-blockage reverser operates to form a barrier in the path of escaping exhaust gases, which nullifies and reverses the forward thrust of the engine.
- In the aerodynamic blockage type of thrust reverser, used mainly with unducted turbofan engines, only fan air is used to slow the aircraft

- If the thrust levers are at idle position and the aircraft has weight on the wheels, moving the thrust levers aft activates the translating cowl to open closing the blocker doors.
- This action stops the fan airflow from going aft and redirects it through the cascade vanes, which direct the airflow forward to slow the aircraft.

Components of thrust reverser system

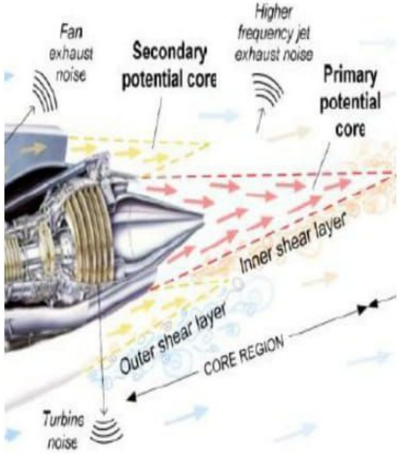


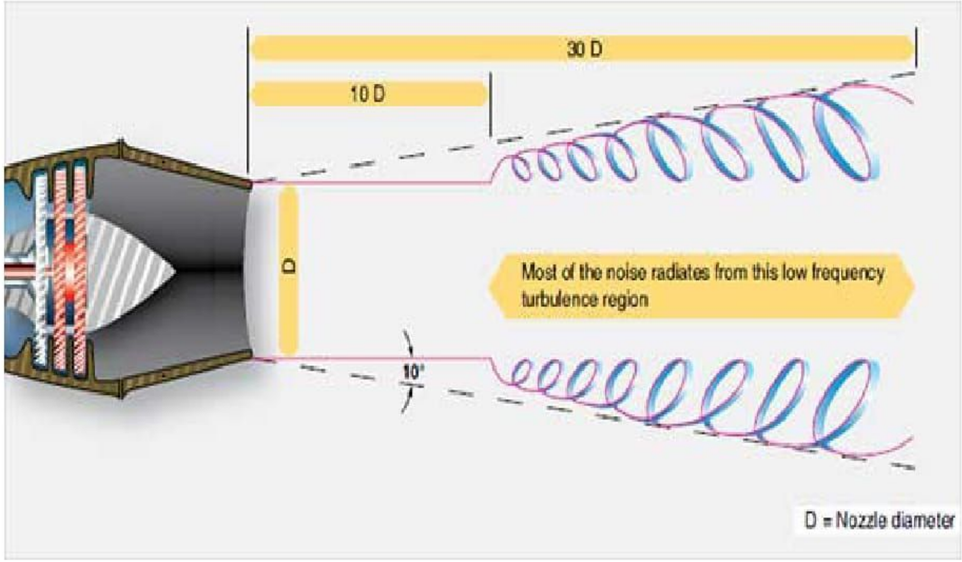
THRUST VECTORING

- Thrust vectoring is the ability of an aircraft's main engines to direct thrust other than parallel to the vehicle's longitudinal axis, allowing the exhaust nozzle to move or change position to direct the thrust in varied directions.
- Military aircraft use thrust vectoring for maneuvering in flight to change direction.
- Thrust vectoring is generally accomplished by relocating the direction of the exhaust nozzle to direct the thrust to move the aircraft in the desired path.
- At the rear of a gas turbine engine, a nozzle directs the flow of hot exhaust gases out of the engine and afterburner.

ENGINE NOISE SUPPRESSION

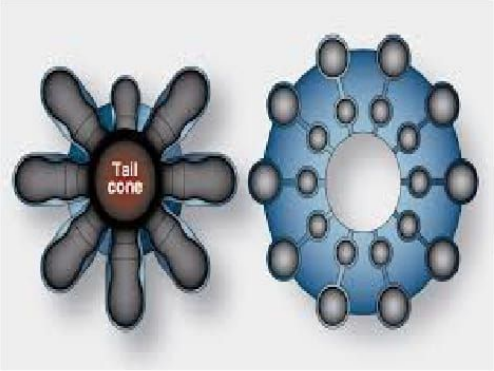
- A common type of noise suppressor is an integral, airborne part of the aircraft engine installation or engine exhaust nozzle
- Engine noise comes from several sources on the engine, the fan, or compressor and the air discharge from the core of the engine
- The noise produced by the engine exhaust is caused by the high degree of turbulence of a high-velocity jet stream moving through a relatively quiet atmosphere
- the turbulence within the high speed jet stream is very fine grain turbulence, and produces relatively high-frequency noise


Fan
exhaust
noise
Secondary
potential core
Higher
frequency jet
exhaust noise
Primary
potential
core
Inner shear layer
Outer shear layer
CORE REGION
Turbine
noise


30 D
10 D
D
Most of the noise radiates from this low frequency
turbulence region
10°
D = Nozzle diameter

- An engine having relatively low airflow but high thrust due to high turbine discharge (exhaust gas) temperature, pressure, and/or after burning produces a gas stream of high velocity and, therefore, high noise levels.
- the noise level can be reduced considerably by operating the engine at lower power settings, and large engines operating at partial thrust are less noisy than smaller engines operating at full thrust.
- The size of the air stream eddies scales down at a linear rate with the size of the exhaust stream. This has two effects:
- 1. The change in frequency may put some of the noise above the audibility range of the human ear, and
- 2. High frequencies within the audible range, while perhaps more annoying, are more highly attenuated by atmospheric absorption than are low frequencies. Thus, the falloff in intensity is greater and the noise level is less at any given distance from the aircraft.

In the engine nacelle, the area between the engine and the cowl has acoustic linings surrounding the engine. This noise-absorbing lining material converts acoustic energy into heat.



BEARING AND SEALS

BEARING TYPE

- Purpose is to take load axial and radial.
- Reduce friction betwType :

– Roller (axial)

– Ball (axial and radial)

– Tappered rollereen shaft and casing